# Status of Forward Hadron Calorimeter (FHCal)

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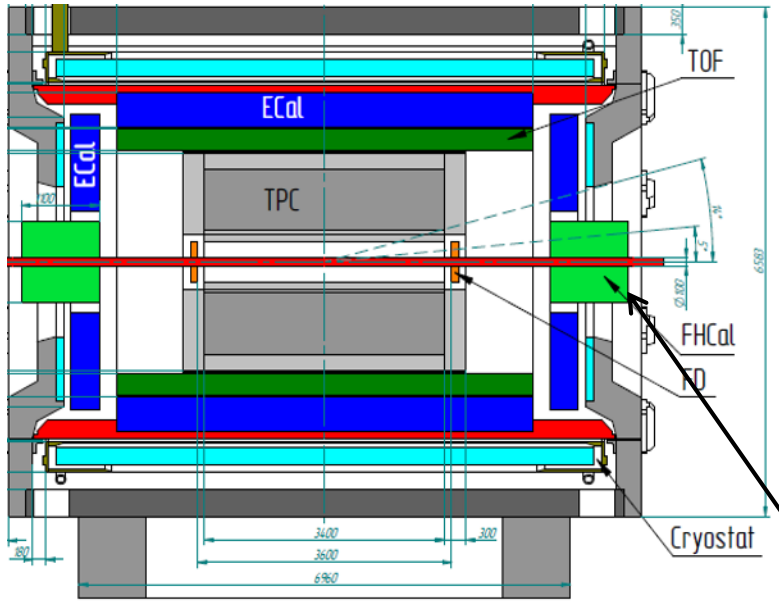
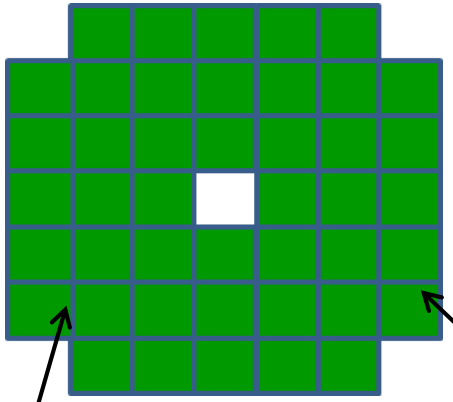
**on behalf of the FHCal group**

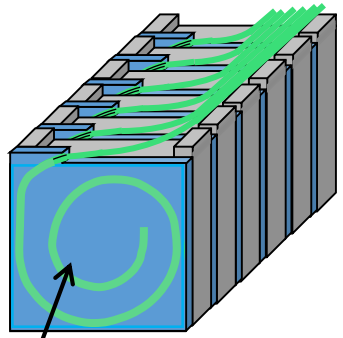
- **FHCal overview;**
- **FHCal modules;**
- **FHCal readout;**
- **FHCal in trigger**
- **Installation to MPD**

**12th MPD collaboration meeting, Oct., 2023.**

# FHCal in MPD





FHCal

FHCal modules

- Two arms of hadron calorimeter at opposite sides in forward regions.
- At the distance 3.2 meters from the interaction point.
- Available acceptance corresponds to pseudorapidity $2.0<\eta<5.0$

- FHCAL consists of 2x44 modules.
- ~1x1 $m^2$ each part.
- Beam hole 15x15 $cm^2$.
- Lead/scintillator sampling calorimeter.
- Longitudinal segmentation;
- Light readout- WLS-fibers;
- 7 sections/photodetectors in each module.

# Tasks of FHCal :

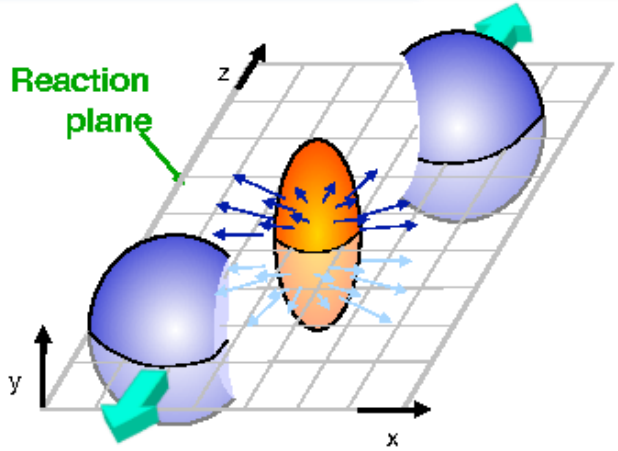
a) The centrality of the collision;

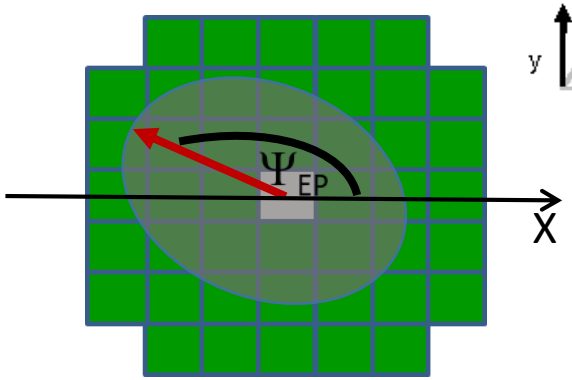
b) The reaction plane orientation;

c) Minimum bias trigger;

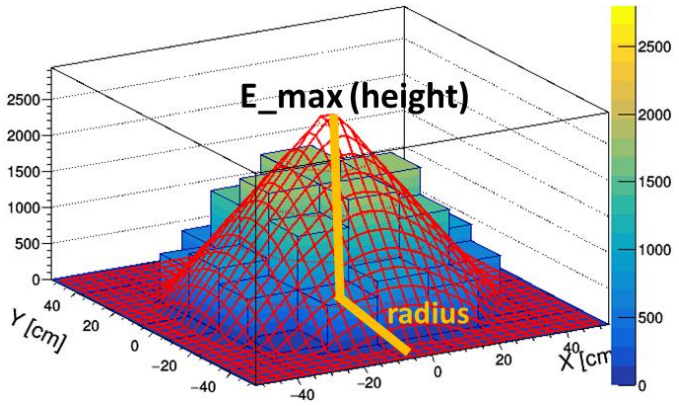
d) Physics in forward rapidity?

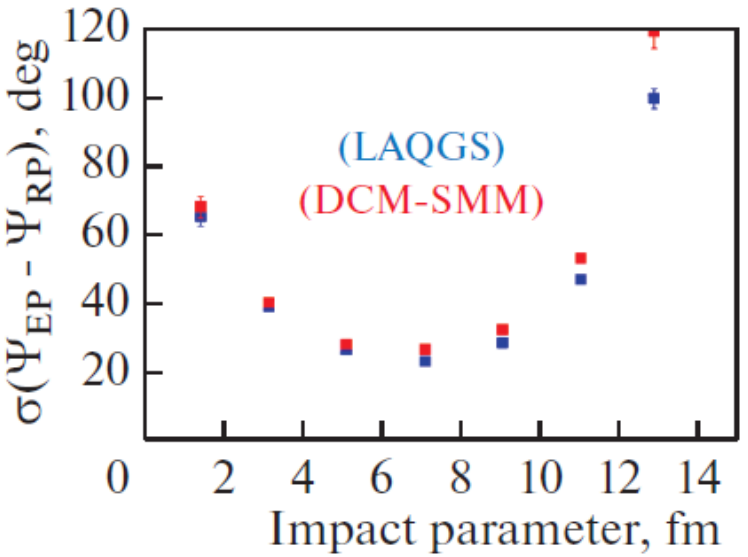
$$\Psi_{EP} = acrtg \frac{\sum E_i \sin(\varphi_i)}{\sum E_i \cos(\varphi_i)}$$



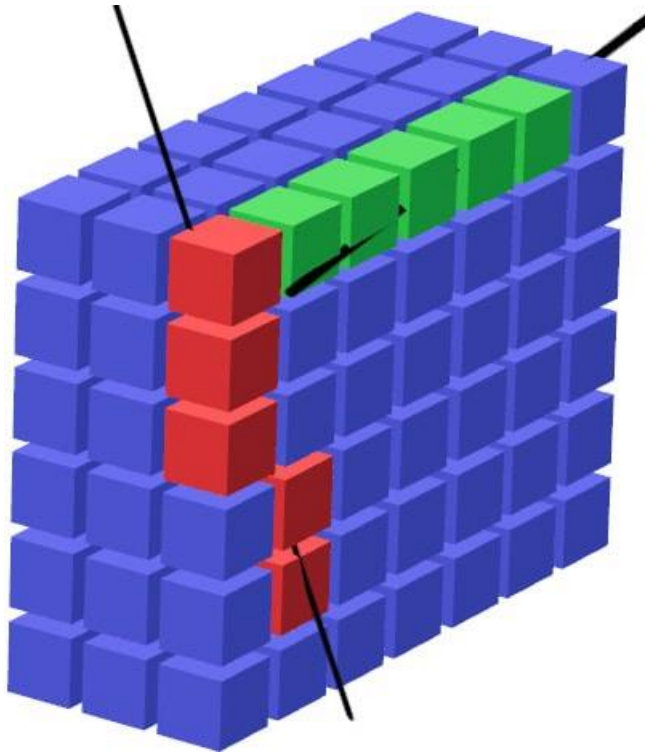

Centrality:
2D-Fit of energy distributions in FHCal modules



# FHCal modules

- All (90+spare) FHCal modules are assembled and tested with cosmic rays.
- Modules are ready for the delivery at MPD site.
- Mini-FHCal is operating now at INR.

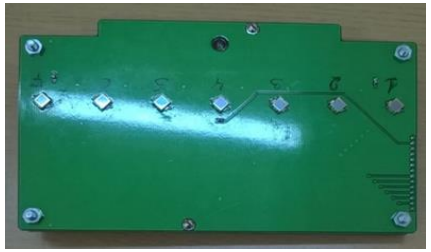


Modules in stockroom

**The activities with modules:**

- Calibration with cosmic muons;
- Development of readout;
- Development of FHCal trigger;
- Development of Detector Control System;
- Monitoring system.

# Readout electronics (FEE)



**MPPC: new type**
**S14160-3010PS**
**size – 3x3 mm²;**
**pixel -10x10 µm²;**
**PDE~18%.**

**Two PCBs in each module with:**

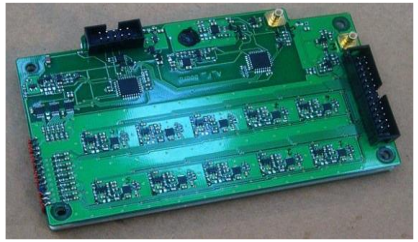
**7 photodetectors ;**

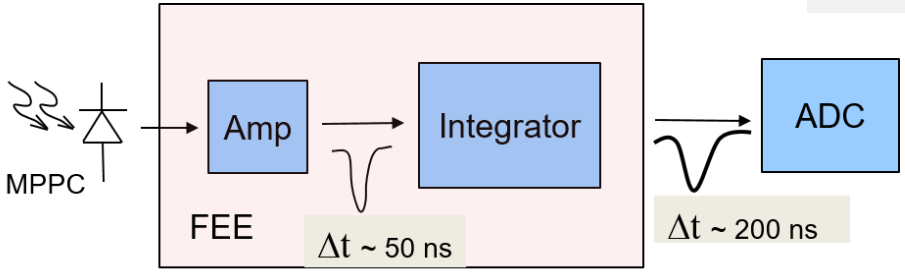
**Photodetectors – MPPCs;**

**two-stage amplifiers;**

**HV channels;**

**LED calibration source.**





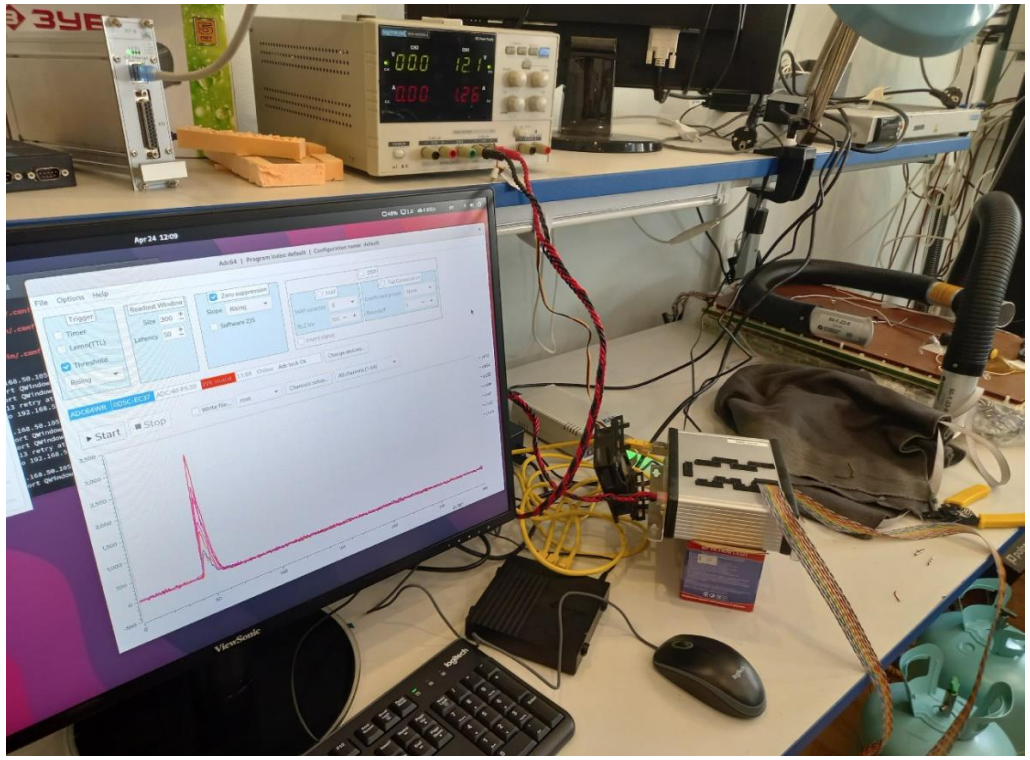

**100 units of FEE were produced and tested.**

# ADCs for FHCal

FPGA based 64 channel ADC64 board, 62.5MS/s (AFI Electronics, JINR, Dubna).

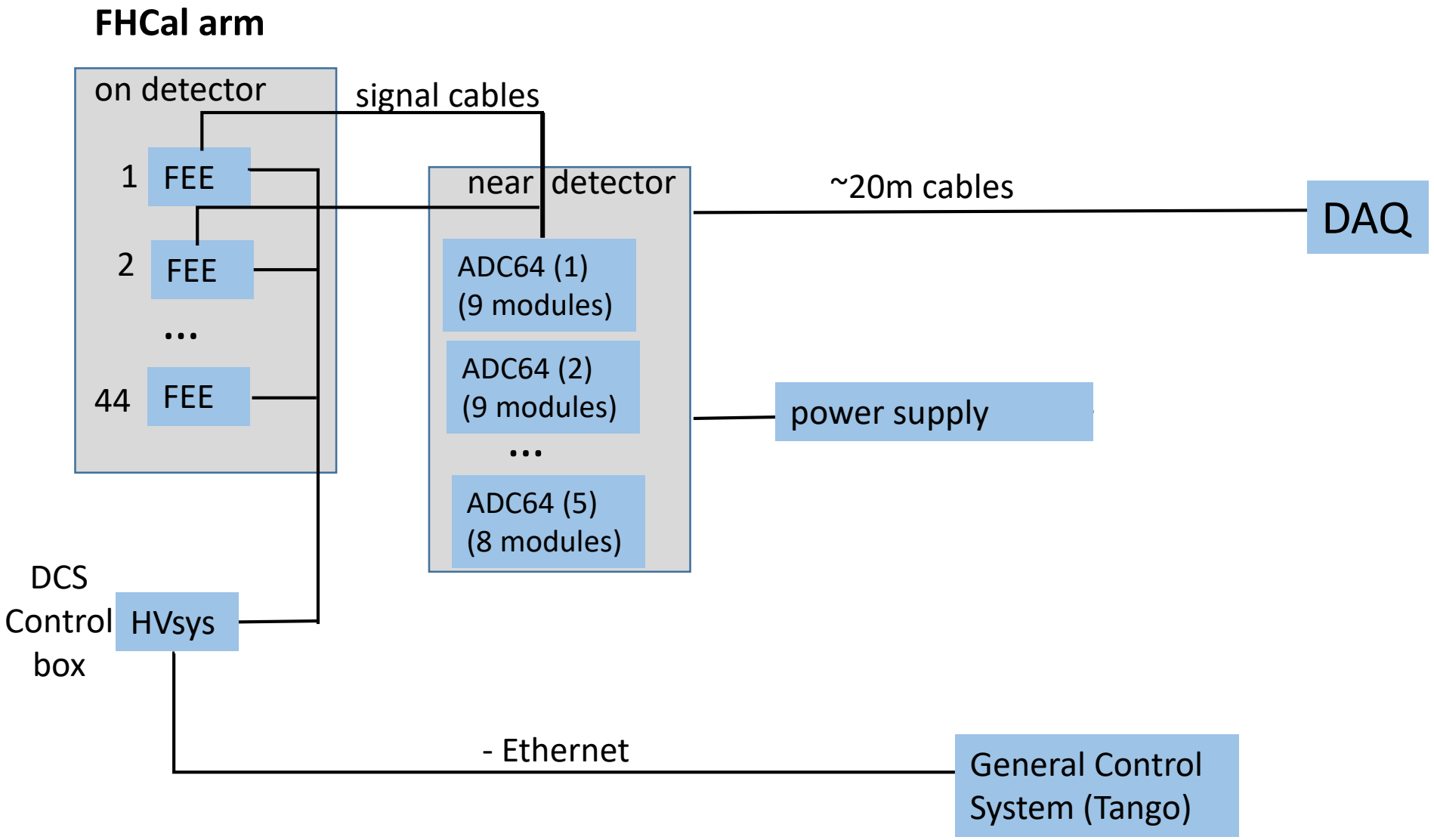
5 ADCs for each part of FHCal

## Bench for ADC tests



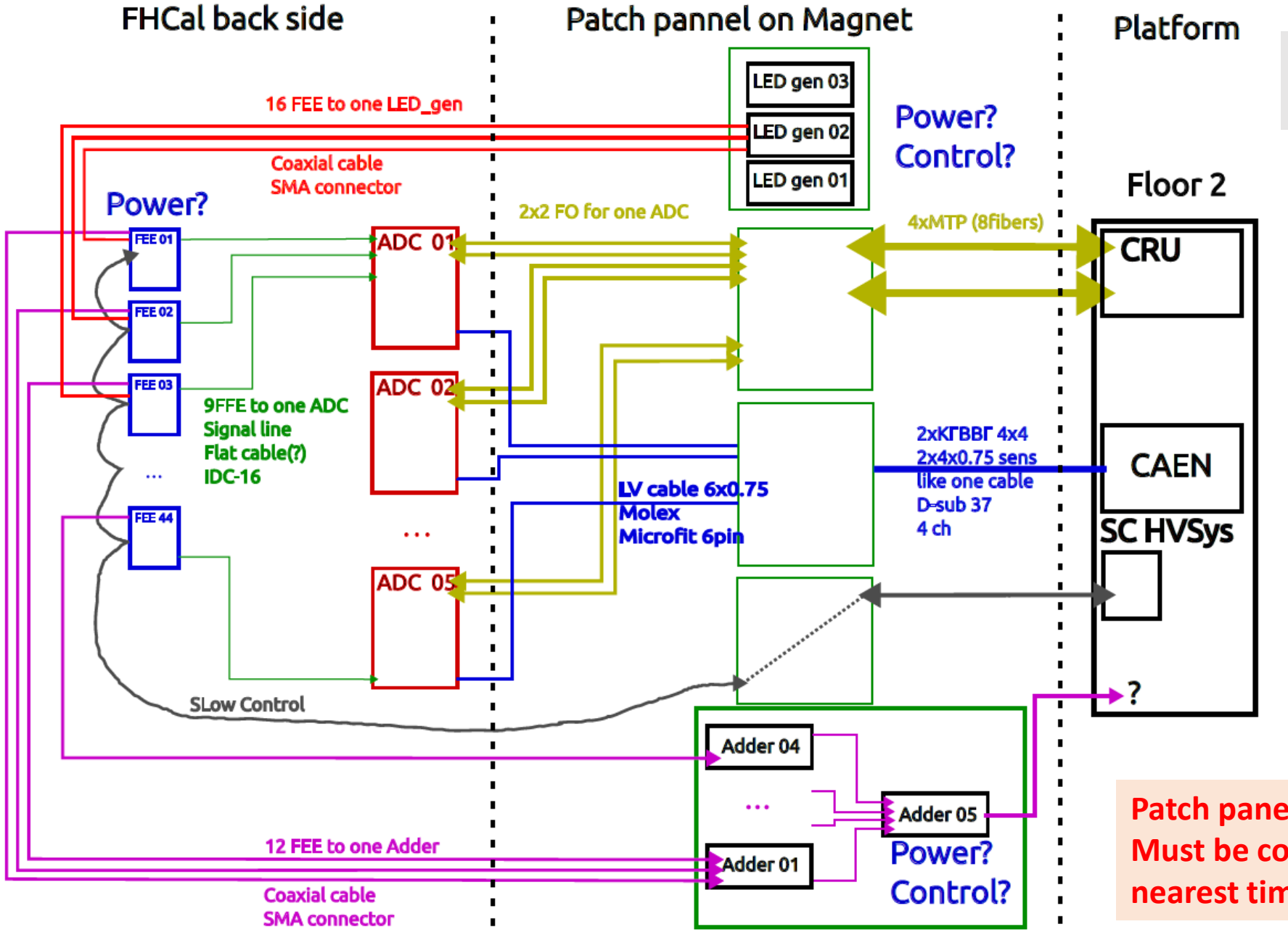
- All 10 ADC boxes were produced last year.
- All ADCs were tested this year at JINR.
- 4 ADCs were repaired during the tests.
- All ADCs are ready for installation.

# FHCal readout and control

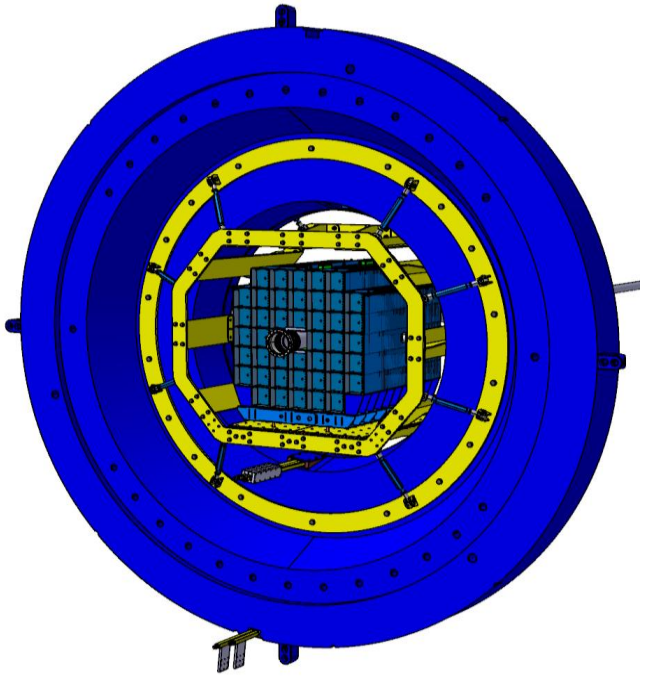



Both FHCal arms have the same readout scheme.

# FHCal cabling




Prepared by
M. Rumyantsev



Patch panel is not ready.
Must be constructed in
nearest time

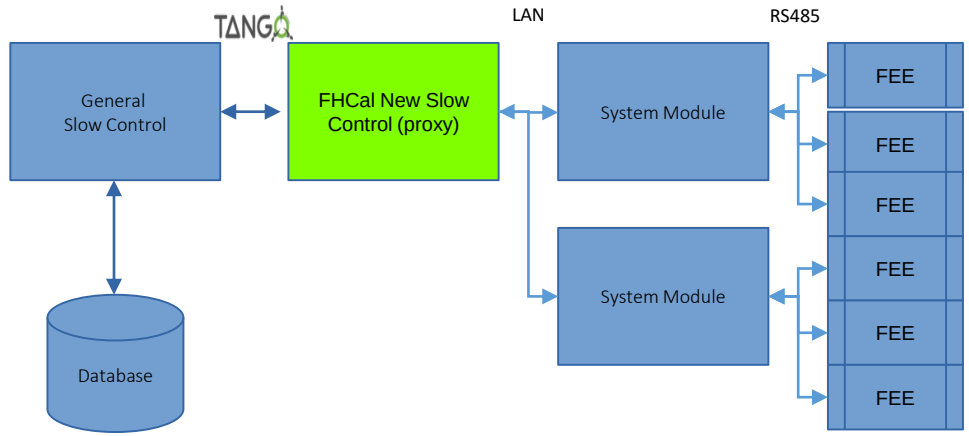
# Detector Control System (DCS)

**DCS Tasks:**

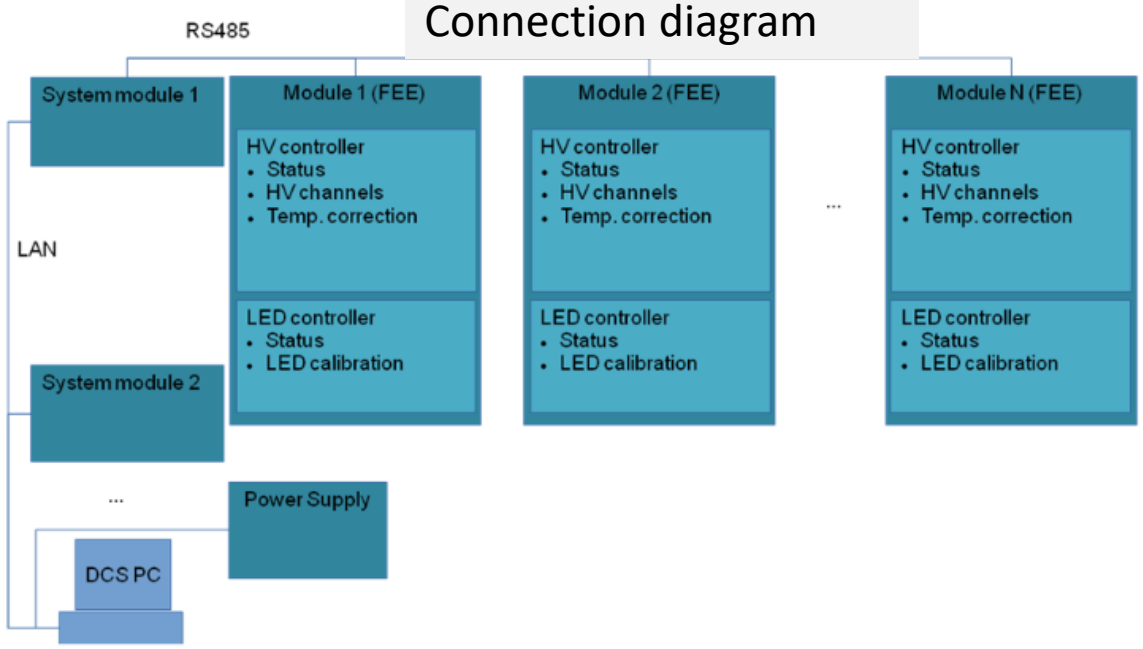
- Control of HV at photodetectors (MPPC's);
- Temperature control of photodetectors;
- Compensation of temperature drift of MPPC gain;
- Monitoring of MPPC gain with stabilized light source.

**Status of DCS:**

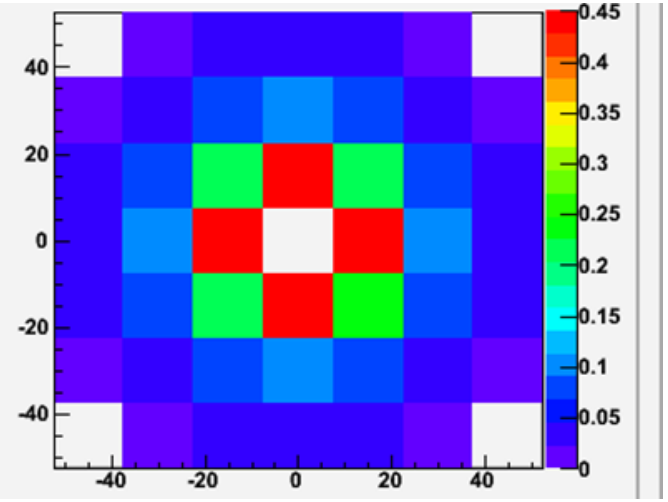
- ➢ It is practically fully operational;
- ➢ Further improvements of functionality are going on.

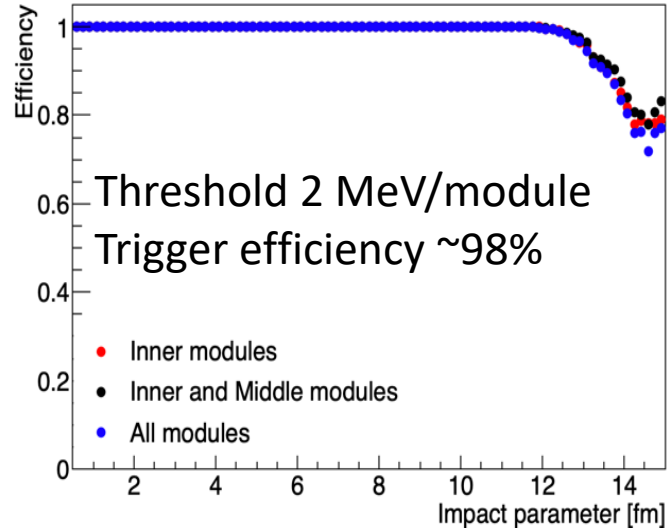



Connection diagram



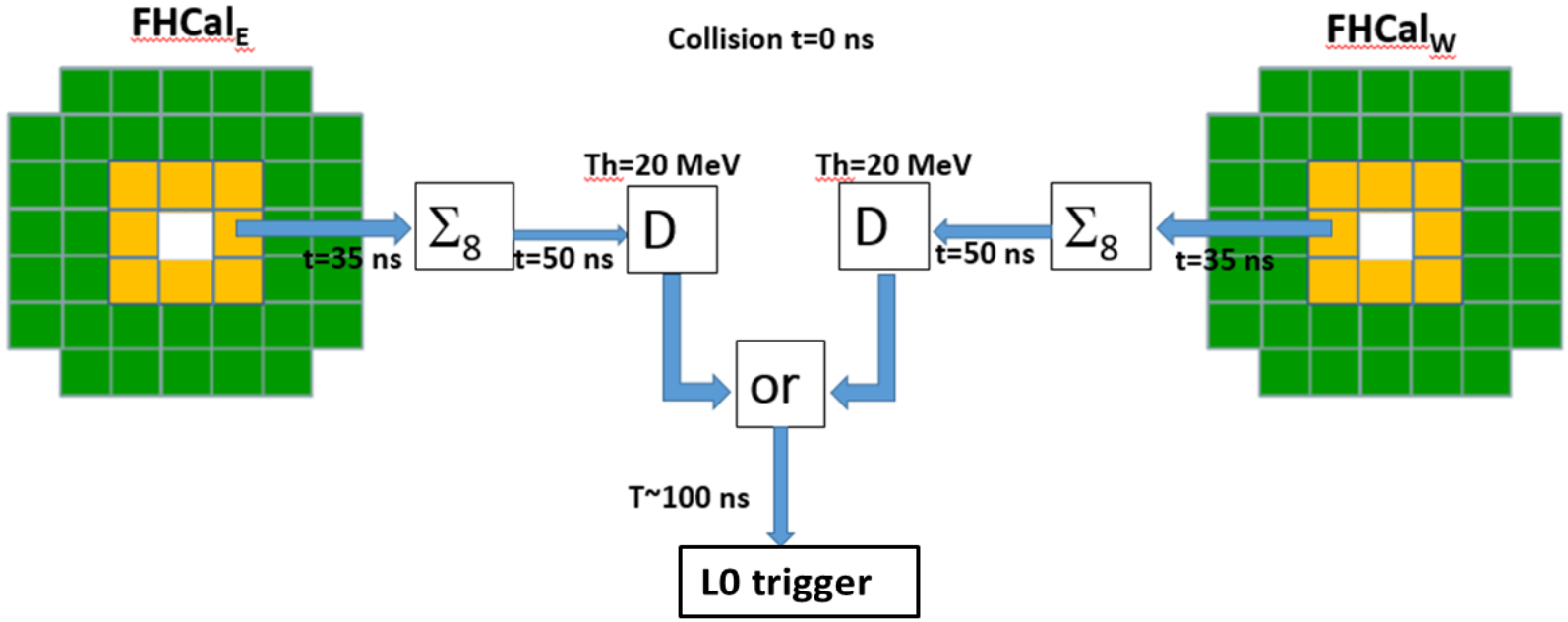
# FHCal in trigger




**Dependence of trigger efficiency on the configuration of modules (Au-Au 11 GeV).**

## Scheme of FHCal trigger

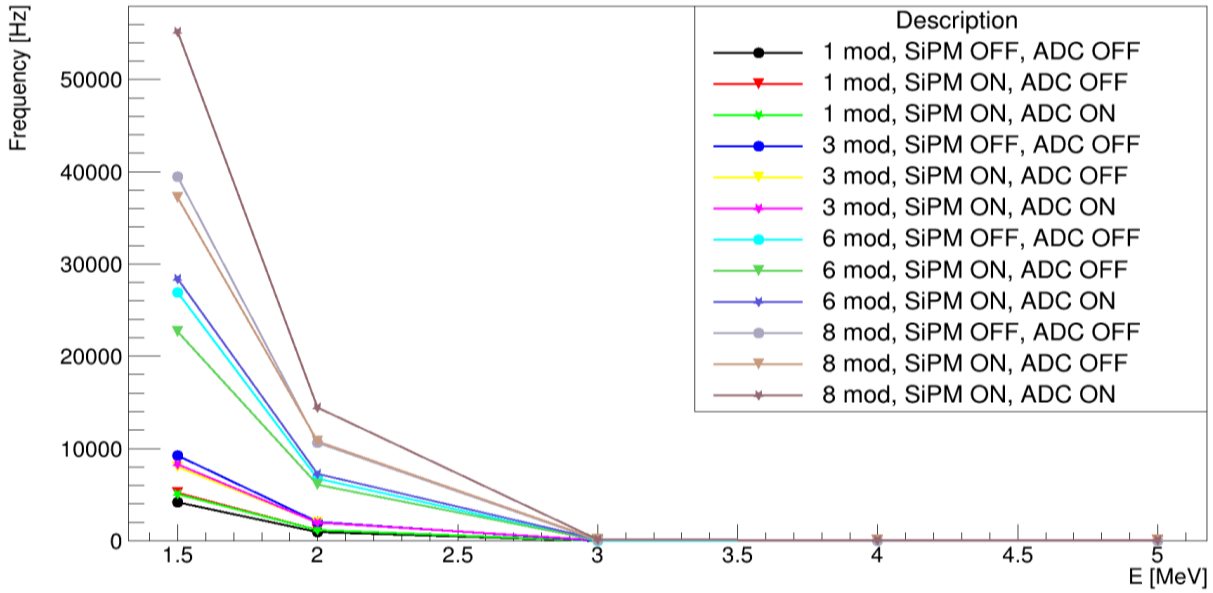


# Preparations for FHCal trigger

- Adders of analog signals from individual modules were produces for full FHCal.
- The configuration of modules in trigger would depend on FEE and correlation noises. Flexible configuration is to be developed.

12-channels signal adders


Dependence of trigger noise on energy threshold

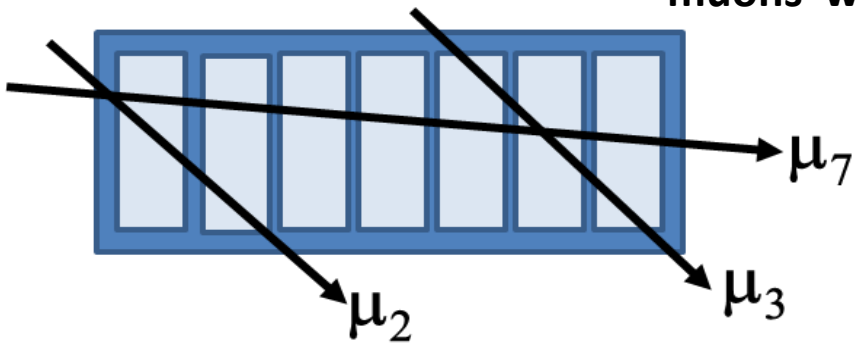


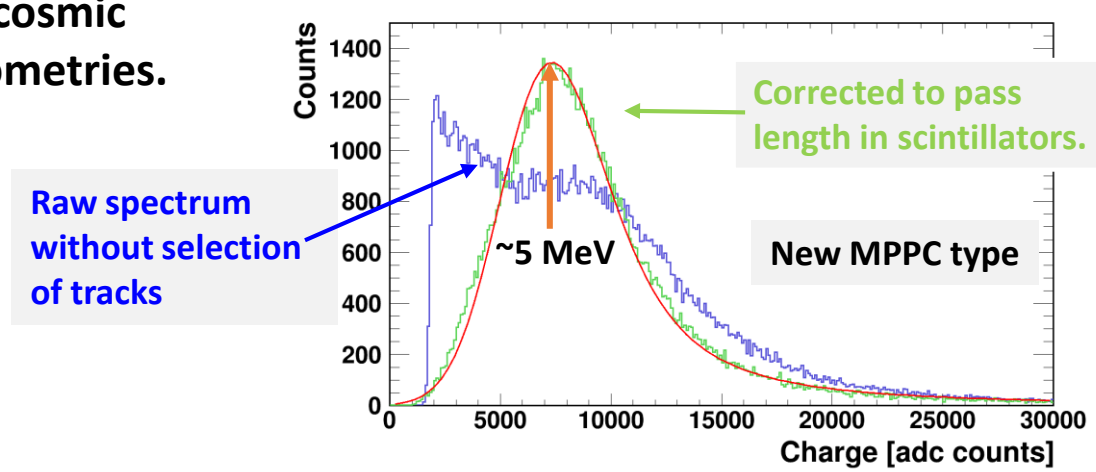

**All adders are working.**
**The noises are under tests.**

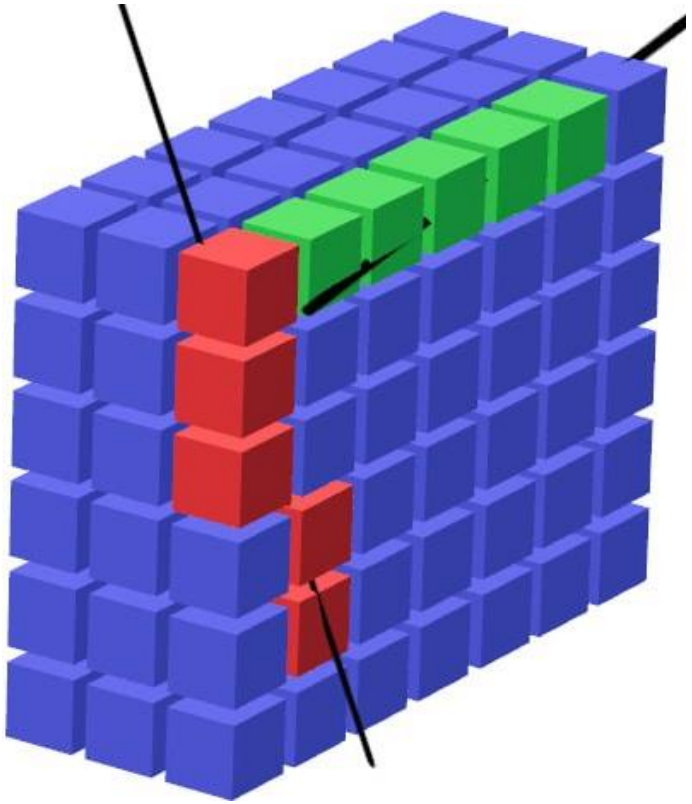
**It seams that 3 MeV threshold is safe for trigger.**

# Energy calibration with cosmic nuons

**Response of FHCal modules to cosmic muons with different track geometries.**

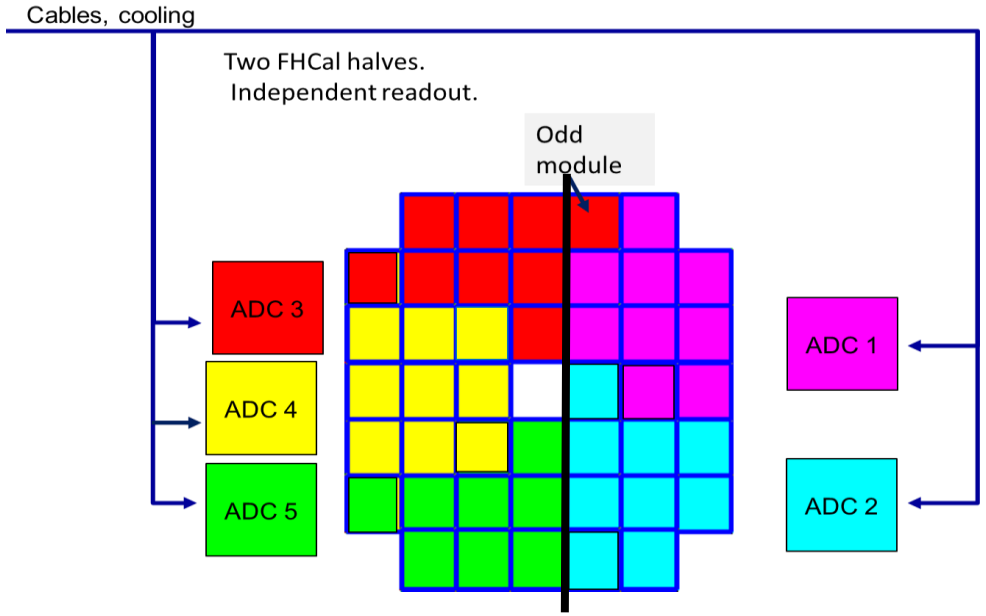


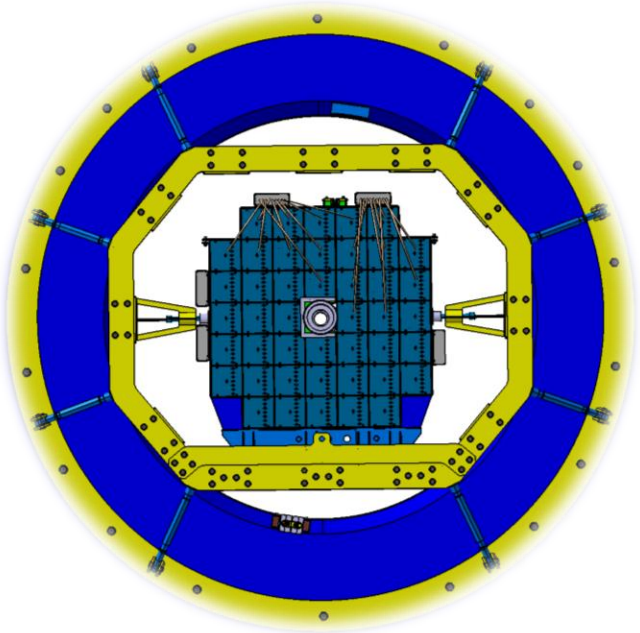
- The energy calibration is planned in self-triggering mode (without external muon trigger).
- The different geometries of muon tracks are to be considered.
- The selection of different muon tracks can be done by requiring the coincidence of muon signals in FHCal modules and longitudinal sections.
- A few versions of energy calibration is under development (with/without correction to pass length).

# FHCal integration to MPD (ADC readout)




Two halves of FHCal.

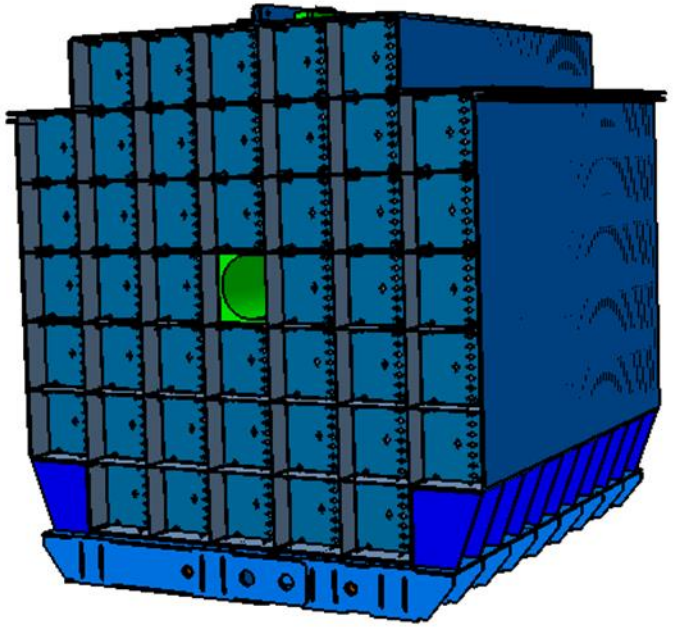
ADC boxes are placed at the lateral sides of FHCal support



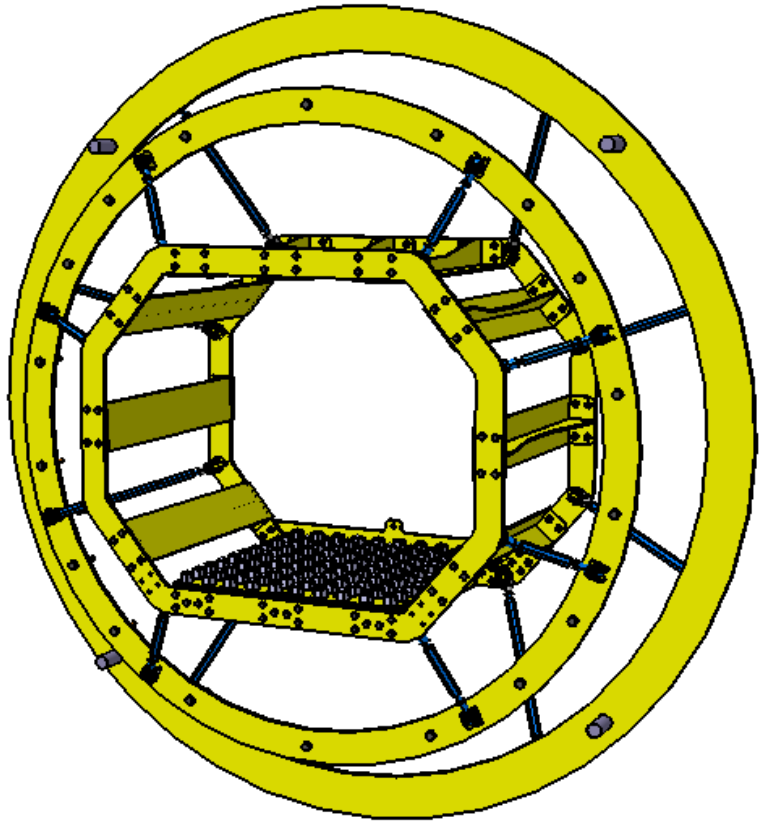
**ADC cooling with compressed air is planned.**
**5 pipes from each side are to be available!**

# Mechanical support (main elements)

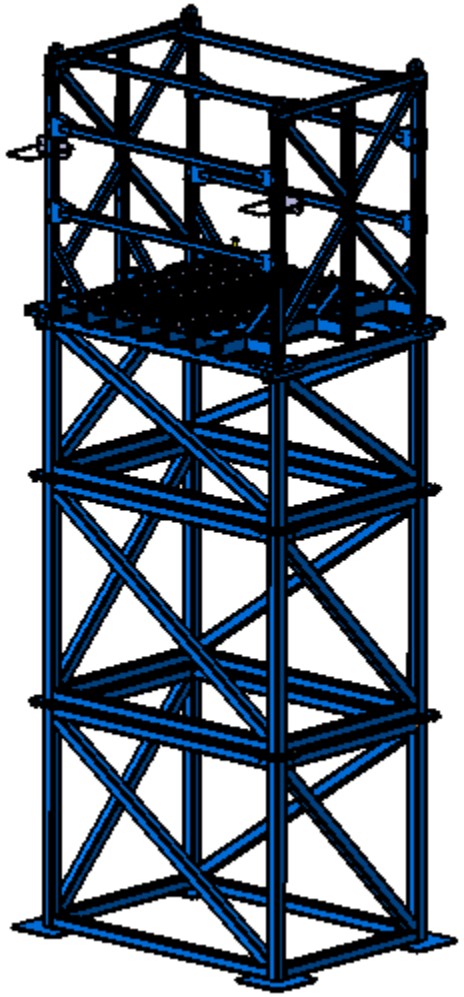
Basket of FHCal modules



Support frame in magnet pole

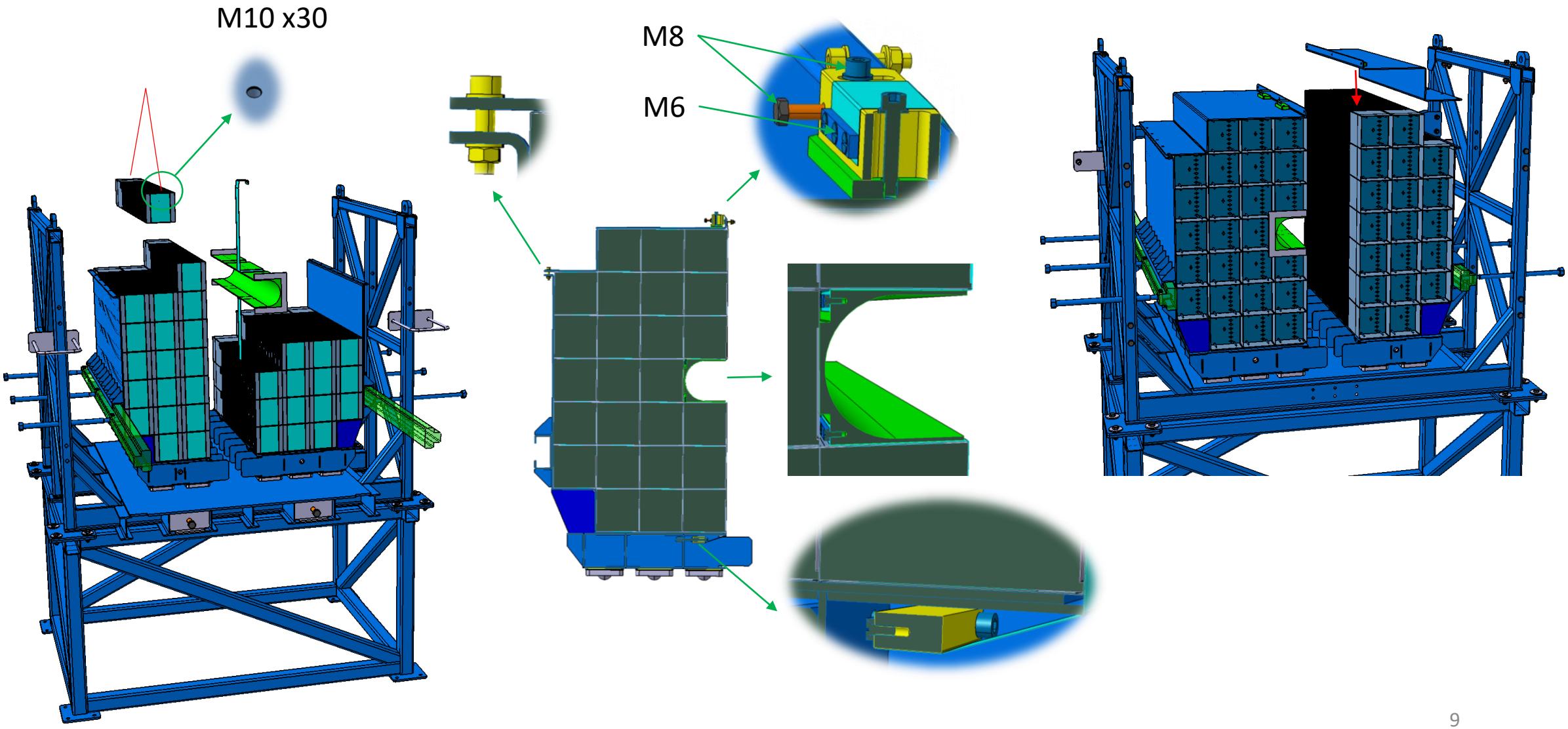


Outer table



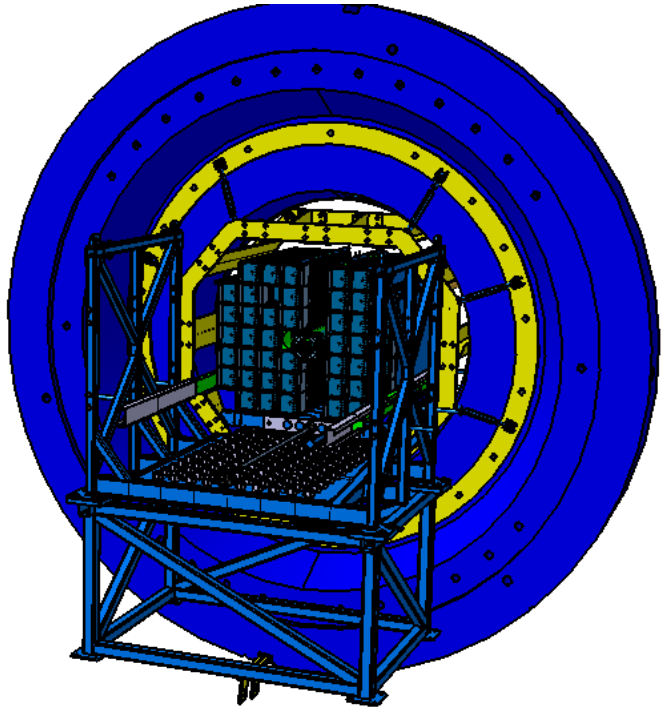
- Design of all elements was finished!
- The production starts now!

# Assembling of FHCal modules in basket

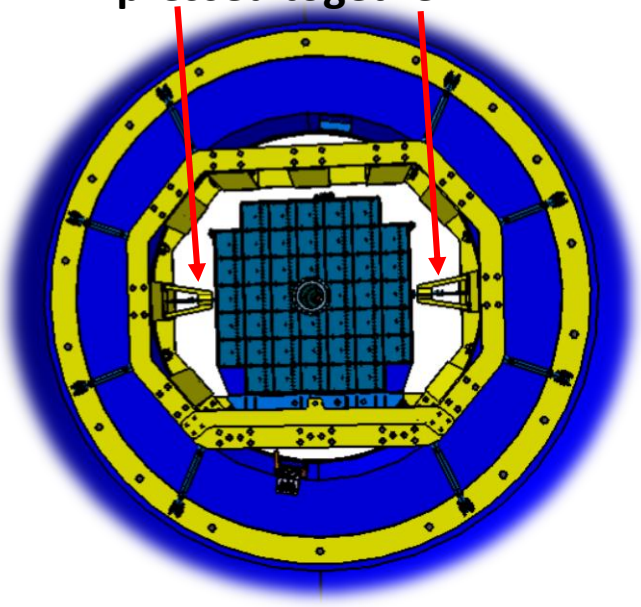


# FHCal installation into magnet pole

**FHCal inserted into pole from inner side**

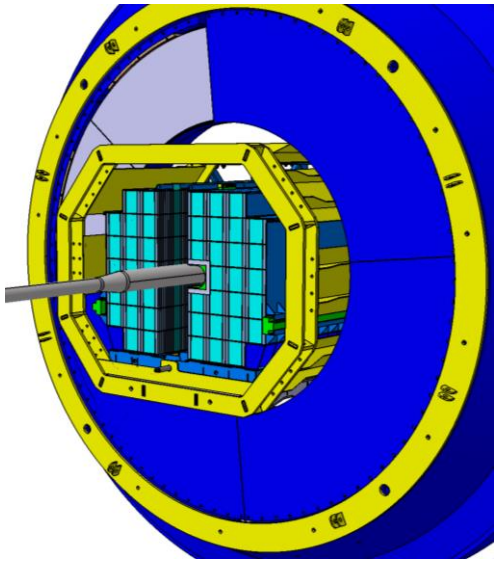


**Two FHCal halves pressed together**

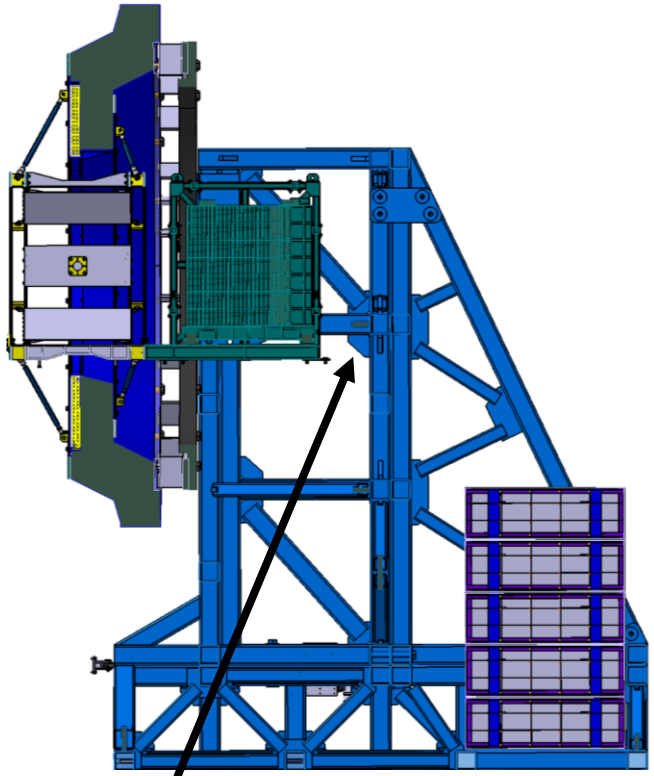


Main problem: beam pipe between two FHCal halves

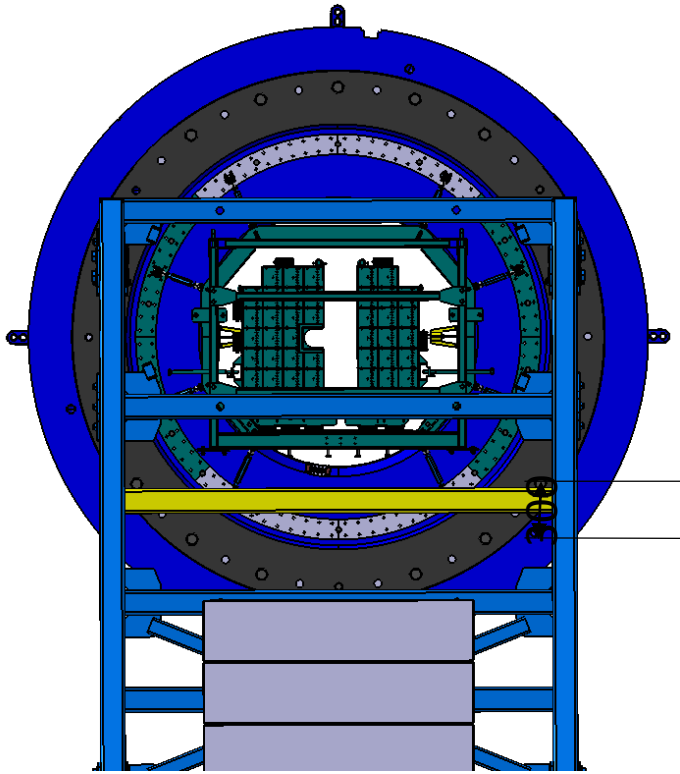


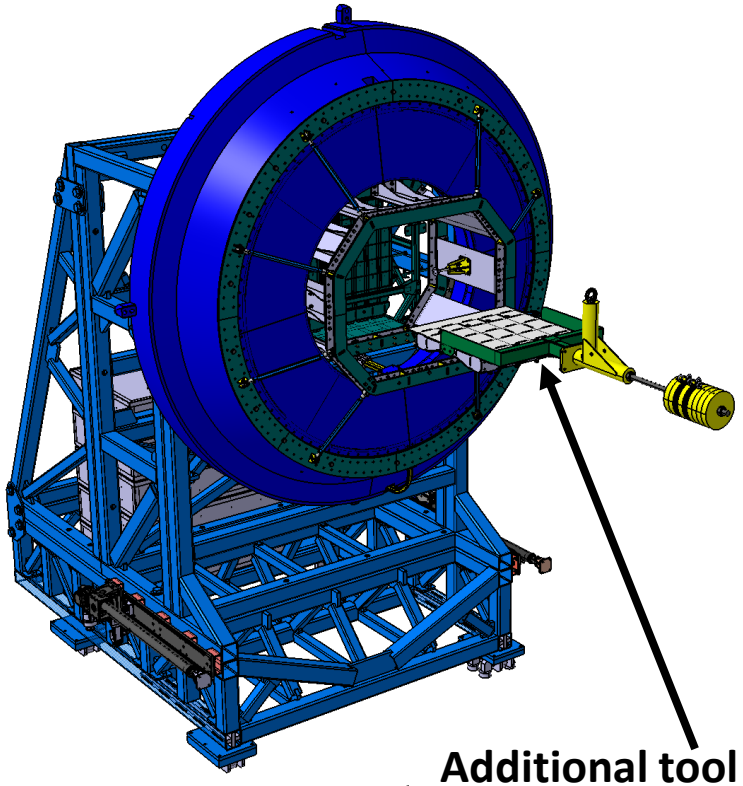


# Alternative way of FHCal installation from outer side of magnet pole

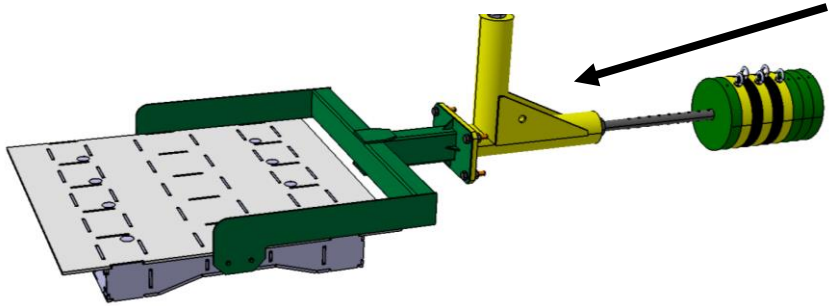


Modification of support is needed





Additional tool is needed



# Summary

- **All FHCal modules were tested and are ready for delivery at MPD site.**
- **FEE was produced and tested.**
- **Detector Control System is ready and is improved permanently.**
- **Energy calibration procedure is optimized.**
- **FHCal trigger is under development. Flexible configuration of modules is considered.**
- **The design of mechanical platform is finished. The production starts now!**

- We plan to start the calorimeter assembling at MPD site in the beginning of 2024.
- The space an some infrastructure for FHCal assembling must be available!

# Thank you!